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METHOD FOR MANUFACTURING ALLOY MONOCRYSTALS  
[Gokin tankessho no seizohoho]

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## Claims

1. Method for manufacturing alloy monocrystals characterized by the fact that in a method for manufacturing alloy monocrystals the composition of which is given by  $\text{Cu-xAl-yM}$  (where  $10 \text{ wt}\% \leq x \leq 20 \text{ wt}\%$ ,  $1 \text{ wt}\% \leq y \leq 10 \text{ wt}\%$ , and M is at least 1 of Ni, Zn or Mn), an alloy having the above composition is processed at a processing rate of 30% or more and after heat-processing wherein it is held at a temperature below the melting point of said alloy but within  $50^\circ\text{C}$  of the melting point, it is quenched from said temperature.

## Detailed explanation of the invention

[0001]

Technical field of the invention

This invention pertains to a method for manufacturing alloy monocrystals that exhibit shape memory and superelasticity.

[0002]

Prior art

Ti-Ni alloys and Cu-Al-M alloys (M is an element such as Ni, Zn or Mn) are known as materials exhibiting shape memory and superelasticity. In particular, Ti-Ni alloys have been placed in practical use in a variety of fields. It is believed that one reason for this is that intergranular fracture occurs less easily for polycrystalline Ti-Ni alloys than for Cu-Al-M alloys. However, because the costs of the starting materials for Ti-Ni alloys are high, increased use is inhibited.

[0003]

Problems to be solved by the invention

On the other hand, the starting materials for polycrystalline Cu-Al-M alloys are relatively inexpensive. However, the crystal grains in polycrystalline Cu-Al-M alloys are large and intergranular fracture occurs easily. Even if the concentration of stress at grain boundaries is alleviated in polycrystalline Cu-Al-M alloys by reducing the crystal grains in hope of preventing intergranular fracture, properties equivalent to or better than polycrystalline Ti-Ni alloys have not yet been obtained.

[0004]

A means for preventing intergranular fracture of polycrystalline Cu-Al-M alloys is removing grain boundaries, that is, forming monocrystals of the Cu-Al-M alloy. If Cu-Al-M alloy monocrystals could be obtained, properties superior to those of Ti-Ni alloys would be obtained and the alloy could be used industrially. Obtaining monocrystals from Cu-Al-M melts by measures such as the Bridgeman method is technically possible. But from the standpoint of practical use of Cu-Al-M alloys, monocrystallization by these measures is very expensive and is unrealistic. Moreover, when growing multi-component alloy monocrystals from melts, a concomitant problem of segregation occurs in many cases.

[0005]

The objective of this invention is to present methods for manufacturing Cu-Al-M alloy monocrystals at low cost.

[0006]

Means to solve the problems

With this invention, it is possible to obtain alloy monocrystals by processing alloys the compositions of which are given by Cu-xAl-yM (where  $10 \text{ wt}\% \leq x \leq 20 \text{ wt}\%$ ,  $1 \text{ wt}\% \leq y \leq 10 \text{ wt}\%$ , and M is at least 1 of Ni, Zn or Mn) at processing rates of 30% or more, then holding at a temperature below the melting point but within 50°C of the melting point, followed by quenching.

[0007]

When Cu-Al-M alloys are heat-processed after being processed at a processing rate of less than 30%, the crystal grains become coarse but do not become monocrystals. Because when Cu-Al-M alloys are processed at high processing rates, since a monophase of only the  $\beta$  phase is brittle and cannot be processed, there is a need to pre-treat at temperatures of 400-600°C to form a mixed  $\alpha + \beta$  phase. When held at a temperature less than the melting point but more than 50°C from the melting point, if it is strongly-processed or heat-treated, the structure becomes fine due to re-crystallization.

[0008]

Embodiment of the invention

Embodiments of this invention will be explained below.

[0009]

For Cu-Al-M alloys wherein M is Ni, Zn and Mn, respectively, that is, for Cu-Al-Ni, Cu-Al-Zn and Cu-Al-Mn alloys, a total weight of 1500 g of metal pieces were melted by high frequency fusion heating and cast in molds. From the cast alloy ingots, 6 mm  $\phi$  round rods were made. The round rods were

cold-processed and wires at a 10-70% processing rate and diameters of 5.4 mm, 4.8 mm, 4.2 mm, 3.0 mm and 1.8 mm, respectively were made. After these wires were held at a temperature of 1050°C for 10 h, they were quenched. The side surfaces of the respective wires were mirror-polished and etched.

[0010]

Table 1 is a table explaining the embodiments of this invention.

[0011]

TABLE 1

①	番号	1	2	3
②	合金系	Cu-Al-Ni系 ⑥	Cu-Al-Zn系 ⑥	Cu-Al-Mn系 ⑥
③	組成 (重量%)	Cu 82.3 Al 13.7 Ni 4.0	Cu 82.0 Al 14.0 Zn 4.0	Cu 81.5 Al 15.5 Mn 3.0
④	⑤ 組織			
	加工率 (%)	10	20	30
		多結晶 ⑦ 粒徑約1mm以下	多結晶 ⑦ 粒徑約5mm以下	多結晶 ⑦ 粒徑約3mm以下
		20	30	40
		多結晶 ⑦ 粒徑約3mm以下	多結晶 ⑦ 粒徑約10mm以下	多結晶 ⑦ 粒徑約5mm以下
		30	40	50
		單結晶 ⑧	單結晶 ⑧	單結晶 ⑧
		50	60	70
		單結晶	單結晶	單結晶
		70	80	90
		單結晶	單結晶	單結晶

Key:	1	Number
	2	Alloy
	3	Composition (wt%)
	4	Processing rate (%)
	5	Structure
	6	Cu-Al-___ type
	7	Polycrystalline
		Grain size less than about ___ mm
	8	Monocrystalline

[0012]

It was confirmed that the 3 kinds of alloys shown in Table 1 all had a single structure and become monocrystals by processing at processing rates greater than 30%. Moreover, the martensite phase transformation completion temperatures  $A_f$  for the Cu-Al-Ni, Cu-Al-Zn and Cu-Al-Mn alloy monocrystals were 55-65°C and 35-45°C, respectively and they all exhibited superelasticity at 70°C, 50°C and 30°C, respectively.

[0013]

Alloy monocrystals can be obtained from Cu-Al-M systems that contain all of Ni, Zn and Mn, or any 2 of these using similar procedures.

[0014]

This invention can manufacture alloy monocrystals at low cost without using expensive devices that are used exclusively for monocrystallization. With this invention, it is not necessary to take segregation in the monocrystallization process into consideration and alloy monocrystals of uniform composition can be obtained, unlike in monocrystallization of multi-component systems that start from melts.

[0015]

Effect of the invention

As explained above, this invention makes possible the manufacture of Cu-Al-M alloy monocrystals at low cost.